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F-19

BULLETIN OF STATIONS FOR OPTICAL OBSERVATIONS

OF ARTIFICIAL EARTH SATELLITES

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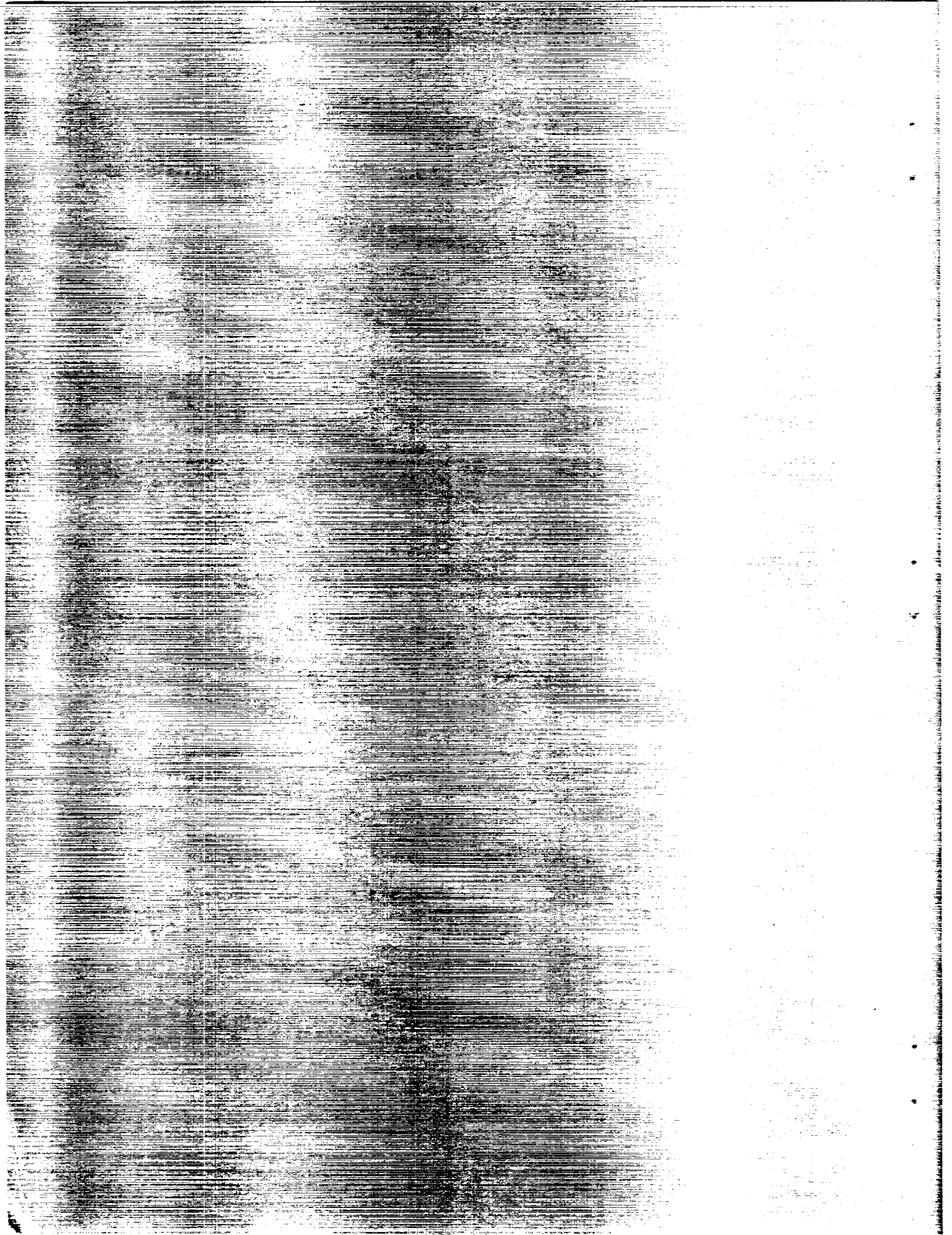
WASHINGTON   May 1960

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

TECHNICAL TRANSLATION F-19

BULLETIN OF STATIONS FOR OPTICAL OBSERVATIONS

OF ARTIFICIAL EARTH SATELLITES*

CONFERENCE OF THE CHIEFS OF STATIONS FOR VISUAL

OBSERVATIONS OF ARTIFICIAL EARTH SATELLITES

By V. A. Tol'skaya**

A conference of the chiefs of stations for visual observations of artificial earth satellites was held in Moscow on 15-17 April 1959.

In the opening address, the vice-chairman of the Astronomical Council of the Academy of Sciences, USSR, A. G. Masevich, noted great improvements in the organization of the work of artificial earth satellite observation stations; recording of time was improved; an exchange of experience between stations was achieved as a result of mutual visits by chiefs of stations and the publication of a bulletin by artificial earth satellite observers.

Scientific associate A. A. Mashkov presented a report entitled "Characteristics of the Orbits of Interplanetary Flights." It was shown that the inclination of the orbit of a planet to the plane of the ecliptic played an important role in determining required speeds.

A report entitled "Concerning the Utilization of Results of Optical Observations of Artificial Earth Satellites" was given by Yu. V. Batrakov (Institute of Theoretical Astronomy). He spoke of programs employed by the ITA [Institut teoreticheskoy astronomii -- Institute of Theoretical Astronomy] for processing observations on electronic machines and of the selection of observations to be included in the processing. In accordance with preliminary systems of elements obtained for the rocket carrier of Satellite No 3, graphs were plotted to show changes of the elements with time. These indicate, for example, that air resistance varies in an irregular manner. In view of the large number of visual observations, it is possible to systematically check all changes occurring in the elements. The only realistic method at present is the combined use of visual and photographic observations

(the latter yield precise values for the height of the perigee and the inclination of the orbit, which cannot be determined with sufficient accuracy by means of visual observations).

Professor V. P. Tsesevich (Odessa) discussed the status of the processing of photometric observations and the method employed for processing these observations in a report entitled "Observations of the Brightness of the Rocket Carrier of Satellite No 3."

V. V. Shmeling (Riga) described an instrument which was designed in Riga to determine the brightness of the artificial earth satellite with the aid of an artificial comparison star (a Graff photometer was used). The recording of the brightness as a function of time was done automatically.

A. A. Kiselev (GAO) [Glavnaya astronomicheskaya observatoriya -- Main Astronomical Observatory (at Pulkovo)] pointed out that it was possible to determine the direction of rotation axis of the satellite by a purely astronomical method, provided that the distance between the center of the mass and the photometric center of the satellite was sufficiently great.

Methods for observing artificial earth satellites were thoroughly discussed at the conference. A. Ya. Virin (Smolensk) and S. A. Leshakov (Petrozavodsk) described the attachment of separate circles and cross wires to the AT-I telescope.

A. G. Sukhanov described a star reference method (privyazka k zvezdam) used at the Vladivostok Observation Station.

V. Ye. Solov'yev (Dnepropetrovsk) and I. A. Klimishin (L'vov) suggested methods for counting local ephemerides.

V. N. Ivanov (Krasnodar) spoke about a network of horizontal coordinates in stereographic projection used at the station in con-junction with a mobile chart. Particular interest was aroused by the report presented by V. V. Shmeling (Riga), Ya. E. Eynasto (Tartu), and A. K. Osipov (Kiev) on methods for automatically recording readings of satellite coordinates. In Kiev, telescope is trained on the satellite with the aid of an electronic circuit (this requires, however, a manual correction with micrometer screws). In the observation stations at Riga and Tartu, training is performed manually. Readings of theodolite circles were photographed at predetermined moments at Kiev and Tartu. At Riga, recording of coordinates as a function of time was done on a rotating drum.

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The problem concerning the comparative advantages offered by star reference methods (privyazka) and methods for conducting observations in a horizontal system of coordinates was discussed in a lively manner. V. I. Kuryshev (cf. Byulleten' stantsiy opticheskogo nablyudeniya ISZ [Bulletin of the Stations for Optical Observation of Artificial Earth Satellites] Nos 1 and 2) described modifications of AT-I telescopes for observations in a horizontal system of coordinates at Ryazan'. The adaptation of AT-I telescopes for observations in a horizontal system of coordinates was also discussed by V. A. Sorokin (Khabarovsk), G. D. Kvirkveliya (Tbilisi), and A. M. Isayev (Baku, where this modification is merely intended). It was noted at the conference that observations in a horizontal system of coordinates can be conducted with sufficient accuracy. Such observations are less laborious than observations made in reference to stars (privyazka). However, the transition to such observations can take place only after a painstaking checking of the unit and with the approval of Astrosovet [Astronomicheskiy sovet -- Astronomical Council].

The problem of photographing artificial earth satellites with small cameras was also discussed at the conference. At Omsk and Orenburg, a "Fotokor" camera shutter is placed in front of the objective of an FED camera, and as a result several breaks can be made in the track, noting corresponding instants with the aid of a chronograph. The shutter of a NAFA-I3 camera was used for this purpose at L'vov. The largest number (60) of photographs of satellites taken with small cameras was obtained at the Vologda Station. Of these, 8 were photographs of Satellite No 3. Objects with a size up to the sixth stellar magnitude were photographed at the station. K. N. Kan (Yuzhno-Sakhalinsk) recommended that the camera be mounted on the AT-I telescope with the aid of screw clamps. At Kzyl-Orda (S. Kh. Khusainov, chief of station), an AT-I telescope is placed in front of the objective of a small camera and as a result stars of the 7-8th magnitude are photographed when taking photos of artificial earth satellites.

Work done at satellite observation stations in Hungary, Rumania, Poland, and the United States was described by colleagues who had visited these countries on a mission.

Ye. Z. Gindin, scientific secretary of the Astronomical Council, read a report entitled "Organizational Problems of Stations Conducting Visual Observations of Artificial Earth Satellites." He noted that, while fulfilling their basic mission, namely observing artificial earth satellites, many stations had also become centers for the dissemination of astronomical knowledge among the population and constituted a primary base for teaching astronomy in higher educational institutions. As for the personnel problem, the stations should strive to: reduce the load on chiefs of stations and their deputies to half

the present level, obtain staff positions of senior laboratory assistant at the stations, and pay for hours spent by station chiefs and their deputies on the organization and conduct of observations at every passage. Ye. Z. Gindin dwelt further on a number of problems connected with the annual reports of the stations.

The conference was ended by drawing up a resolution directed toward further improvement of the organization of the work of the stations and improvement of methods for observing satellites.

CHANGES IN THE BRIGHTNESS OF THE ROCKET CARRIER

By V. P. Tsesevich

Abstract

As is well known, the brightness of rockets varies.
In this article the theory of determining the axis-
direction is described. Both cases, specular and diffuse
reflection of light from the body, are discussed.

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The rocket carrier and the artificial satellite change in bright-
ness as a consequence of rotation about their transverse axes. When
the rotation about the axis is slow as, for example, in the case of
Satellite No 2, it is possible to evaluate the brightness and to plot
smooth curves. The rocket carrier of Satellite No 3 changed its
brightness so rapidly that it was impossible to evaluate its bright-
ness, and it was necessary to resort merely to determining moments of
maximum brightness.

These observations were received by the Odessa Observatory.
Observations from the following stations were examined critically and
have gone through a primary processing stage: Abakan-68, Abastumani-113,
Arkhangel'sk-135, Astrakhan'-388, Vil'nyus-762, Vologda-782, Moscow-30,
Dnepropetrovsk-152, Yerevan-64, Irkutsk-514, Kazan'-515, Krasnodar-152,
Leningrad-108, Minsk-2, Nikolayev-405, Novosibirsk-97, Odessa-5800,
Omsk-678, Orenburg-1387, Pulkovo-685, Riga-572, Riga (Klevetskiy)-1259,
Ryazan'-774, Sakhalin-523, Sverdlovsk-80, Smolensk-79, Tashkent-329,
Tashkent (Kozik)-315, Uzhgorod-235, Ufa-3, Frunze-142, Khabarovsk-385,
Chernovtsy-421. The total exceeded 18,000 visual observations of moments
of maximum brightness.

This article is concerned with methods for processing these
observations.

I. For this processing it is essential to adopt one of two
hypotheses. The first hypothesis assumes that the body of the rocket
reflects light vertically. The second assumes that an ideal diffuse
light scattering takes place.

The basic premises are the following: the body of the rocket
has the form of a cylinder having a length l and a cross-section
diameter a. It is assumed that the rocket rotates about axis W,
which is perpendicular to the longitudinal axis of the cylinder.

The following coordinate system is selected: the origin of the
coordinate system is placed at the center of gravity of the rocket.
Axis $0\,\xi$ is directed towards the point of the vernal equinox, axis

O ξ towards the pole of the world. We connect with these axes an equatorial rocket-centered system of spherical coordinates. The axis of rotation, the vector OW will have "equatorial coordinates" in the celestial sphere of the rocket: right ascension K and declination D (Figure 1).

Let us select an auxiliary system of coordinates U, V, W. We select axis OU in such a way that it will be perpendicular to OW and will lie in the plane ξ O η. Point U may be called the initial point of the proper rotation of the rocket. Axis OV is perpendicular to OU and OW.

As it is considered that the longitudinal axis of the rocket OX is perpendicular to OW, then at a certain time T_0, OX coincides with OU.

Later, the angle $\varphi = \angle$ UOX will play a major role.

This angle may be calculated from the formula:

$$\varphi = \Omega (T - T_0) \tag{1}$$

where T is the time of observation, $\Omega = \dfrac{360^{o}}{P}$, P is the period of proper rotation of the rocket about the axis.

The point in the rocket-centered celestial sphere at which OX intersects this sphere has the coordinates: σ - declination and α - direct ascension. These magnitudes can be found by using the formulas:

$$\sin \sigma = - \sin \varphi \cos D; \quad \text{ctg} (\alpha - K) = - \text{tg} \varphi \sin D. \tag{2}$$

Let us introduce two unit vectors: ς_1 - extending from the center of the rocket to the sun, and ς_2, extending from the center of the rocket to the observer. These vectors can be found by using the formulas:

$$\varsigma_1 \xi = \cos \alpha_\odot \cos \sigma_\odot; \quad \varsigma_1 \eta = \sin \alpha_\odot \cos \sigma_\odot; \quad \varsigma_1 \zeta = \sin \sigma_\odot$$
$$\varsigma_2 \xi = \cos \alpha_H \cos \sigma_H; \quad \varsigma_2 \eta = \sin \alpha_H \cos \sigma_H; \quad \varsigma_2 \zeta = \sin \sigma_H. \tag{3}$$

Here $\alpha_\odot$ and $\sigma_\odot$ are the equatorial rocket-centered coordinates of the sun, which are equal to its geocentric coordinates.

The magnitude α_H and σ_H are the equatorial rocket-centered coordinates of the observer, which are calculated from the visible topocentric coordinates of the rocket α_p and σ_p in accordance with the formulas:

$$\alpha_H = \alpha_p \pm 180° \quad \text{and} \quad \delta_H = -\delta_p.$$

Vector G_3 (not a unit vector) is important for the hypothesis of specular reflection of light. This vector is equal to the vector sum of G_1 and G_2. It bisects the angle formed by these 2 vectors, so that the angle of incidence of the rays is equal to the angle of reflection, and lies in the same plane as these vectors. The formulas for calculating this vector are obvious:

$$G_{3\xi} = G_{1\xi} + G_{2\xi}, \quad G_{3\eta} = G_{1\eta} + G_{2\eta}, \quad G_{3\zeta} = G_{1\zeta} + G_{2\zeta} \tag{4}$$

The point of the rocket-centered celestial sphere at which the vector intersects its surface has the equatorial coordinates α_N and δ_N.

These coordinates can be derived from the formulas:

$$\operatorname{tg}\alpha_N = \frac{G_{3\eta}}{G_{3\xi}}; \quad \operatorname{tg}\delta_N = \frac{G_{3\zeta}}{\sqrt{G_{3\xi}^2 + G_{3\eta}^2}} \tag{5}$$

When studying the set of maximum brightness moments of the rocket, it is essential to calculate at different moments the α_N and δ_N as functions of time. Their graphic representation on the rocket-centered celestial sphere yields a trajectory of the tip of vector G_3, which we call "the bend of the normal" (kryuk normali).

In the same way, magnitudes α_H and δ_H, considered as time functions during their graphic representation on a rocket-centered celestial sphere, also yield a trajectory of the tip of vector G_2, which we shall call the "bend of the observer" (kryuk nablyudatelya). These graphic representations are of assistance in solving the problem.

2. The hypothesis of specular reflection. If the surface of the rocket reflects light like a mirror, then at a certain angle of deflection φ_M an observer would notice a bright flash on the rocket's surface. It is at this instant that we would record a flash. The angle φ_M corresponds to that position of axis OX in which the normal to the body of the rocket coincides with vector G_3. Consequently $X_\xi G_{3\xi} + X_\eta G_{3\eta} + X_\zeta G_{3\zeta} = 0$, which, after taking into account the formulas:

$$X \xi = \cos \varphi \sin K + \sin \varphi \cos K \sin D$$

$$X \eta = - \cos \varphi \cos K + \sin \varphi \sin K \sin D$$

$$X \zeta = - \sin \varphi \cos D$$

yields

$$\operatorname{ctg} \varphi_M = \sin D \operatorname{ctg} (d_N - K) - \cos D \operatorname{tg} \alpha_N \operatorname{cosec} (d - k) \quad (6)$$

Knowing φ_M from observations (and having calculated α_N and α_N), we can determine K and D, the direction of the axis of rotation.

How is it possible to determine the magnitude φ_M from observations of brightness?

If the length of the period of rotation of the rocket P is known, this is not difficult to do.

The observed moments of maximum brightness can be expressed by: $M_B = M_0 + PE$, where M_0 is the initial time of the maximum, E is a whole number of revolutions, M_B is the calculated "ephemeridal" moment of maximum brightness. Since the rocket changes its position in space, the observed maximum moments will differ systematically from the calculated moments. This gives rise to the deviations $M_{obs} - M_{cal} = 0 - C$, which precisely characterize changes occurring in the angle φ_M; these changes are designated by us as $\Delta \varphi_M$. They may be found by using the formula $\Delta \varphi_M = \frac{360}{P}(0-C)$.

The magnitudes $\Delta \varphi_M$, which are known from observations, do not as yet enable us to make use of formula (6), since the latter does not include $\Delta \varphi_M$, but rather magnitude φ_M itself. Therefore, formula (6) is rewritten thus for practical use:

$$\operatorname{ctg} (\varphi_0 + \Delta \varphi_M) = \sin D \operatorname{ctg} (d_N - K) - \cos D \operatorname{tg} \alpha_N \operatorname{cosec} (d_N - K) \quad (6A)$$

There are now three unknowns φ_0, K, and D in this equation, which is not so easy to solve. In order to solve this equation, we select such a "bend of the normal" in which α_N remains constant (this happens sometimes). Then the solution of the problem is simplified. We designate the constants:

$$A = \sin D \operatorname{ctg} (d_N - K), \quad B = \cos D \operatorname{cosec} (d_N - K) \quad (6B)$$

and obtain $\operatorname{ctg} (\varphi_0 + \Delta \varphi_M) = A - B \operatorname{tg} \alpha_N.$ \quad (6C)

We select three points with the same value of d_N, find the corresponding O-C, through them $\Delta \varphi_{M1}$, $\Delta \varphi_{M2}$, and $\Delta \varphi_{M3}$ and set up three equations:

$$\text{ctg} (\Delta \varphi_{M1} + \varphi_o) = A - B \, \text{tg} \, d_{N1}$$

$$\text{ctg} (\Delta \varphi_{M2} + \varphi_o) = A - B \, \text{tg} \, d_{N2} \qquad (6D)$$

$$\text{ctg} (\Delta \varphi_{M3} + \varphi_o) = A - B \, \text{tg} \, d_{N3}$$

Eliminating A and B, we find the relationship

$$\frac{\text{ctg} (\Delta \varphi_{M1} + \varphi_o) - \text{ctg} (\Delta \varphi_{M2} + \varphi_o)}{\text{ctg} (\Delta \varphi_{M1} + \varphi_o) - \text{ctg} (\Delta \varphi_{M3} + \varphi_o)} = \frac{\text{tg} \, d_{N2} - \text{tg} \, d_{N1}}{\text{tg} \, d_{N3} - \text{tg} \, d_{N1}} \qquad (6E)$$

From this equation, the right member of which is known, we determine φ_o, after which we find A and B, and finally K and D.

We present a numerical example for 28 July 1958

d_N	d_N	O-C	$\Delta \varphi_M$	φ_M	
130º2	- 45º0	- 0,000011	- 19º6	28.4	
158.0	- 30.0	- 0,000021	- 37.4	10.6	
168.0	- 11.0	- 0,000025	- 44.6	3.4	
169.2	+ 1.9	- 0,000024	- 42.8	5.2	*
169.1	+ 10.2	- 0,000022	- 39.2	8.8	*
168.8	+ 17.1	- 0,000015	- 26.7	21.3	*
168.2	+ 20.4	- 0,000006	- 10.7	37.3	

The values which are used in calculations are marked in this table by asterisks. From them were obtained the values $\varphi_o = 48$, A = 12.00; B = 30.65; K = 167º, D = 21º. However, complete presentation of all remainders O-C showed that there is a conflict between the theoretical and the observed course. This provides evidence against the hypothesis of specular reflection of light from the rocket.

3. **The hypothesis of diffuse light scattering.** Rare observations in which the rocket ceased to show fluctuations in brightness and shone quietly, with a steady maximum brightness, also contradict the hypothesis of specular light scattering. Such a phenomenon would be impossible in case of specular reflection. Therefore, the hypothesis of an ideal diffuse light scattering by the cylindrical body of the rocket was investigated. According to this hypothesis, the illumination per unit of surface of the body of the rocket is proportional to the cosine of the angle of incidence of the rays, and the brightness of the investigated surface is proportional to the cosine of the angle formed by the

line of vision and the normal to this surface. Let vector ρ_1, which connects the center of gravity of the rocket with the sun, intersect the rocket surface at point S (Figure 2).

The plane running through OX and OS will prove to be of major importance later. Let us construct the vector a, which lies in this plane and is perpendicular to OX. Then the normal S_n is parallel to this vector. The angle $\Lambda S \rho_1$ is designated by ω_0.

We shall select on the body of the rocket elementary areas having a width dS and a length ℓ. In case of a certain area of this type, the normal will be represented by the vector 0ℓ. All normal vectors will lie in a plane running through the origin of the coordinates, which is perpendicular to the line OX. We shall read the angles ψ between the normals and vector $0a$. Now, let us introduce the vector ρ_2, which connects the center of gravity of the rocket with the observer. The brightness of any elemental area is calculated according to the formula:

$$d\mathfrak{J} = \mathfrak{J}_0 \cos W \cos X\, \ell\, dS \qquad \text{where}$$

W is the angle between 0ℓ and ρ_1,
X is the angle between 0ℓ and ρ_2.

Generally speaking, for any law of diffuse scattering, it would be necessary to introduce an additional factor $\tau(W, X)$, which expresses the law of light scattering. We assume that $\tau(W, X) = I$, since we are investigating an ideally diffusing body. Now, it is necessary to determine the angles W and X and integrate over the entire illuminated surface of the rocket. For this purpose, we shall use Figure 3, illustrating everything that is shown in Figure 2, but with no details. Figure 3 shows the presence of spherical triangles.

OS - direction of the sun
OT - direction of the observer
0ℓ - normal vector
$0a$ - initial normal vector
Arc ℓ S = W. Arc ℓ T = X.
Arc SX = 90° - W_0. Arc TS = τ.
Arc TX = σ. Arc$a\ell$ = ψ. Points a and ℓ are located at a distance of 90° from X.
From $\Delta \ell$ SX we find: $\cos W = \cos W_0 \cos \psi$.
From $\Delta \ell$ TX we find: $\cos X = \sin \sigma \cos(\psi + \varkappa)$.
Element of length $dS = a\, d\psi$
Thus $d\mathfrak{J} = \mathfrak{J}_0 a \ell \cos W_0 \sin \sigma \cos \psi \cos (\varkappa + \psi) d\psi$
Consequently: $\cos (\psi + \varkappa) \sin \sigma = 0$.
From here, either $\sigma = 0$, or $\psi + \varkappa = \pm \dfrac{\pi}{2}$ and $\psi = \pm \dfrac{\pi}{2} - \varkappa$.

The terminator takes place when $W = 90°$.

Consequently: $\cos W_0 \cos \Psi = 0$, and either $W_0 = 90°$, or $\Psi = \pm \frac{\pi}{2}$

By selecting the needed values of $\Psi_1 = - \frac{\pi}{2}$ and $\Psi_2 = \frac{\pi}{2} - \varkappa$, we obtain:

$$J = \int_{-\frac{\pi}{2}}^{\pi/2 - \chi} J_0 \, a\ell \cos W_0 \, \sin\delta \cos\Psi \cos(\Psi - \chi) d\Psi = J_0 \frac{a\ell}{2} \cos W_0 \sin\delta$$

$$\left\{(\pi - \varkappa) \cos \chi + \sin\chi\right\} \tag{6F}$$

Denoting $F(x) = (\pi - \chi) \cos x + \sin x$, we obtain a formula for calculating the brightness of the rocket:

$$J = J_0 \frac{a\ell}{2} \cos W_0 \sin\delta \, F(x) \tag{7}$$

From the spherical triangle TSX, we find the auxiliary formulas:

$$\cos\delta = \sin\delta_H \sin\delta + \cos\delta_H \cos\delta \cos(\alpha - \alpha_H)$$

$$\sin W_0 = \sin\delta_0 \sin\delta + \cos\delta_0 \cos\delta \cos(\alpha - \alpha_0) \tag{8}$$

$$\cos\tau = \sin\delta_H \sin\delta_0 + \cos\delta_H \cos\delta_0 \cos(\alpha_0 - \alpha_H)$$

Angle χ is found from the formula:

$$\cos\chi = \frac{\cos\tau - \cos\delta \sin W_0}{\sin\delta \cos W_0} \tag{9}$$

By using the set of formulas (7) and (9) it is possible, knowing the direction of axis OW and having used formula (2), to calculate the brightness curve of the rocket.

Such calculations were performed for the case investigated above (in particular for $K = 167°$, $D = 21°$). Plausible brightness curves were obtained.

5. In order to determine K and D from observation data according to brightness curves or more accurately, on the basis of maximum moments, it would be necessary to find dJ/dt, set it equal to zero, and find Ψ_M. This is generally impossible. However, two graduate students from Odessa University, V. Pozigun and Surkov, were able to simplify the solution of this problem. While carrying out calculations

of theoretical curves, they noticed that maximum brightness occurred almost at the same time that the product $f = \sin W_0 \cos \sigma$ reached its lowest value. Then, having found:

$$\frac{d f}{\partial \varphi} = \frac{\partial f}{\partial \sigma} \frac{d\sigma}{d\varphi} + \frac{\partial f}{\partial d} \frac{dd}{d\varphi} = 0 \qquad (9A)$$

and using the expressions given above, we obtain a formula for finding $z = \operatorname{tg}\varphi_M$ in the explicit form $z^2 - \dfrac{T}{S} z - 1 = 0$

where $T = -2 [\sin D \cos D (C \cos\theta + E \cos\Psi) + B \sin^2 D \cos\Psi \cos\theta$

$+ A \cos^2 D - B \sin\Psi \sin\theta]$

$S = B \sin D (\sin\Psi \cos\theta + \cos\Psi \sin\theta) + \cos D (C \sin\theta + E \sin\Psi)$

$A = \sin\sigma_H \sin\sigma_{\odot}$; $B = \cos\sigma_H \cos\sigma_{\odot}$; $C = \sin\sigma_H \cos\sigma_{\odot}$;

$E = \cos\sigma_H \sin\sigma_{\odot}$; $\theta = d_H - K$; $\Psi = d_{\odot} - K$.

$$(9B)$$

In the last equation

$$\operatorname{tg}\varphi_{M1} \operatorname{tg}\varphi_{M2} = -1; \quad \operatorname{tg}\varphi_{M1} + \operatorname{tg}\varphi_{M2} = \frac{T}{S} \qquad (9C)$$

where φ_{M1} and φ_{M2} are two roots of the equation. From here, tg $(\varphi_{M1} + \varphi_{M2}) = \dfrac{T}{2S}$. On the other hand, $\varphi_{M2} - \varphi_{M1} = 90°$, consequently tg $\left(\dfrac{\pi}{2} + 2\varphi_{M1}\right) = \dfrac{T}{2S}$, and we obtain the basic formula: ctg $2\varphi_{M1} = -\dfrac{T}{2S}$.

Reduction of the formula to explicit form made it possible to calculate angles φ_{M1}, if the direction cosines of the rotation axis W are known. However, this formula does not permit to solve the reverse problem, which consists in determining the direction cosines of the rotation axis on the basis of angles φ_{M1} known from observations.
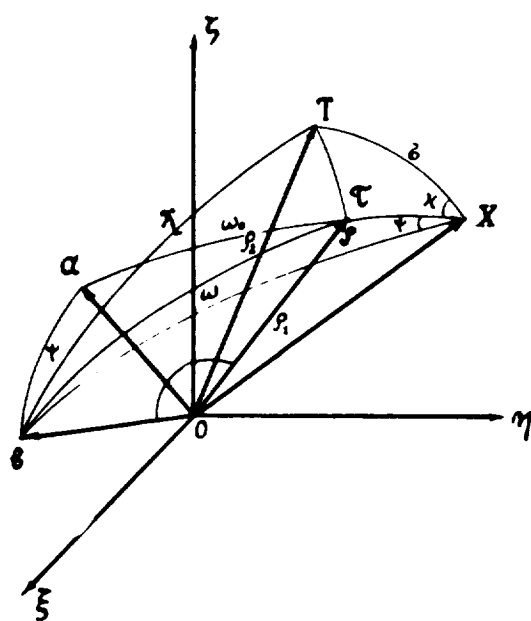
Figure 1

Figure 2

Figure 3

THE ROTATION PERIOD OF THE ROCKET CARRIER OF THE

THIRD SOVIET ARTIFICIAL SATELLITE 1958 δ_1

By V. P. Tsesevich*

Abstract

It is shown that the moments of maximum brightness throughout all passages can be presented by a linear expression. Such expressions were obtained for every day of August. It appeared that the period of rotation changed with a period of 3.5 days on August 1-11. This variation being excluded, a new, longer period of period variation was discovered.

This article presents a numerical study of the formula $\operatorname{ctg} 2\varphi_{M1} = -\dfrac{T}{2S}$ for one particular case. It was assumed that the point at which the rotation axis of the rocket intersects the celestial sphere had the coordinates $K = 0$ and $D = 30$ (K - direct ascension, D - declination in the rocket-centered equatorial coordinate system). After substituting into the formula the equatorial coordinates of the sun for 5 August $\alpha_\odot = 135°$ and $\delta_\odot = 17°$, and assigning different values for the direct ascensions and declinations of the observer α_H and δ_H, we calculated the values of angle φ_{M1} and plotted lines of equal angles on a graph.

A study of the graph led to the following results.

In case of declinations δ_H of less than $-30°$, and widely different values of α_H, the angles φ_{M1} differed little from each other. This indicates that all observers, for whom the apparent declination of the rocket is greater than $+30°$, should observe the maximum [brightness] moments of the rocket as if they were taking place simultaneously, without the effect of the geographical coordinates of the observation point.

Rapid and considerable changes of angle φ_{M1} are observed if δ_H is greater than $-30°$, particularly if the line of sight connecting the observer with the rocket has approximately the same direction as the line of sight connecting the center of the rocket with the sun. If the trajectory of the observer in the rocket-centered coordinate system lies in the region $\alpha_H \sim 160° - 170°$ and $\delta_H \sim 0°$, then one should expect rapid changes in angle φ_{M1} and a distortion in the time of maximum [brightness].

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Such a semiqualitative study of the formula helped us to gain an understanding of the phenomena which were occurring.

Thus we can draw two conclusions:

A) If the "position of the observer" is far from the "position of the sun," changes in the angle of rotation of the rocket can be neglected. Consequently, such observations of times of maximum brightness can be used for determining the true sidereal period of rotation of the rocket. Observations which fall within the "forbidden" region should be rejected.

B) After the period of the rocket has been found, it is possible to calculate values of angles ψ_{M1}, and the observations which were rejected as having been most affected by the position of the rotation axis can then be used for finding the magnitudes K and D.

Observations which had been made at various stations from 2 to 8 August 1958 inclusive were subjected to a final analysis. Graphs were plotted, which showed the movement of the observer through the celestial sphere of the rocket, i.e., the "observer's bend," and the necessary series of observations were selected on the basis of condition A.

During the period from 2 to 8 August inclusive, the series of observations was particularly good. Frequently the same passage was observed at many stations.

The following method was employed when analyzing the observed times of maximum brightness.

All observations made by different stations at the time of one of the passages were represented by a linear period formula $M_E = M_0 + P.E(2)$, where M_0 is the initial time of the maximum, P is the accepted value of the period, E is an integer, the number of the maximum M_E. Thus, we obtained the calculated time of the maximum M_{Ecal} and set up the difference $M_{Eobs} - M_{Ecal}$. The trend of these differences was studied.

An example of such a representation of differences in "Obs - Cal" values plotted on a graph is given in Figure 1. E values are plotted on the abscissa and the "Obs - Cal" discrepancies for different stations are plotted on the ordinate.

Figure 2 shows a trend (or course) of differences, during which one of the stations happened to be located in the "critical" region. Obviously its observations were temporarily rejected as they come under condition B.

As a rule, the majority of the graphs resembled the curves of Figure 1.

A mean value was obtained from all the times that satisfied condition A. This mean yielded a time of maximum brightness which was characteristic for a complete passage observed at many points.

These times are given in the following table.

Table of Averaged Times of Maximum Brightness (Table 1)

Max.	E	Obs.-Cal.	M'	M' - Cal.
2.674658	0	+ 1	2.674415	+ 7
.747172	710	+ 4	.747879	+ 2
.817632	1400	- 4	.817295	-10
.890441	2113	-12	.890065	-15
.963177	2825	+ 8	.962768	+15
3.744061	0	- 7	3.743770	- 5
.817279	717	+10	.817038	+ 7
.887923	1409	+ 5	.887734	+ 1
.961422	2129	- 4	.961291	- 4
4.600430	0	- 4	4.600785	-15
.740824	1374	+10	.741243	+20
.813150	2082	0	.813593	+13
.883842	2774	- 9	.884300	- 3
.958539	3505	+ 3	.959002	- 9
5.527111	0	+ 1	5.527380	- 4
.598662	699	+13	.598881	+15
.666911	1366	- 2	.667077	+ 1
.736801	2049	-14	.736911	- 9
.811315	2777	- 7	.811364	- 5
.881017	3458	- 2	.881007	- 3
.955233	4183	+14	.955162	+11
6.524267	0	+ 9	6.523836	+32
.594421	686	- 9	.593971	- 7
.665609	1382	-15	.665147	-29
.805150	2746	+ 1	.804686	-20
.876752	3446	- 1	.876298	-14
.949194	4154	+19	.948757	+20
7.728646	0	-	7.728737	-
804500	742	-	7.804652	-
8.513078	0	+ 3	8.513545	-15
.587676	729	+ 3	.588136	+ 3
8.659194	1428	- 8	8.659641	+ 3
.727041	2091	- 5	.727468	+ 8
.796113	2766	- 6	.796514	+ 5

(Table 1, continued)

.868288	3471	+27	.868655	+27
.946939	4240	-14	.947262	-31

After this, the times [of maximum brightness] observed during different passages were correlated by means of linear period formulas of type (2). It was found that the observations made for all passages of the same calendar date were related, a fact which made it possible to determine very accurately the values of the period for a given calendar date (as is well known, the period changes).

The following formulas were obtained from the data listed in the table above:

1 August   2.82   Max = $2.674657 + 0.000102128 \ E_1$
2 August   3.85   Max = $3.744068 + 0.000102094 \ E_2$
3 August   4.80   Max = $4.600434 + 0.000102160 \ E_3$
4 August   5.77   Max = $5.527110 + 0.000102345 \ E_4$
5 August   6.74   Max = $6.524258 + 0.000102291 \ E_5$
6 August   7.76   Max = $7.728646 + 0.000102229 \ E_6$
7 August   8.73   Max = $8.513075 + 0.000102330 \ E_7$

The "Obs - Cal" differences from these formulas and corresponding figures are given in the second and third columns of Table 1. Figures are given to the sixth place after the decimal point, which corresponds to 0.1 seconds. In addition, values of the period for adjoining dates were estimated (but not subjected to final processing). For August 1.8, P = 0.00102170; for August 9.8, P = 0.000102349 and for August 10.8, P = 0.000102297. An examination of the difference trend shows that these differences do not exceed 10% of the value of the period, which is entirely acceptable.

3. Changes in the period of rotation show that it is variable. This is a fact that has been known for a long time. It was found, however, that the period changes in a most unexpected manner. In Figure 3, the dates are plotted on the abscissa and the values of the period given above are plotted on the ordinate.

It was discovered that the period changes periodically, at that same time it lengthens. The periodic variation of the period was found to be equal to 3.5 days, which corresponds to an increase in E of 34,500 units.

The magnitude of the period was represented by the following approximate empirical formula:

$$P = 0.0001011143 + 0.00000002284 \; \varepsilon - 0.0000001434 \; \varepsilon^2 + 0.000000085$$

$$\sin(0°.010433.E - 154°.3), \tag{3}$$

where E is calculated from the time 1958 August 0.0 and $\varepsilon = E/10000$.

Formula (3) can and should be improved in the following manner. A formula representing the time of maximum [brightness] must be obtained from it by integrating and selecting a suitable value of an arbitrary constant. Formula (4) was obtained in this manner:

$$\text{Maximum for 1958 August 0.0} - 0.006645 + 0.0001011443.E + 0.001142 \; \varepsilon^2$$

$$- 0.0000495 \; \varepsilon^3 - 0.000457 \cos(0°.010433.E - 154°.3) \tag{4}$$

Then, one should calculate the ephemeride, find the deviations of each maximum [brightness] moment and construct arbitrary equations with seven unknown factor corrections. Unfortunately, this cannot be done at this particular stage. Terms which contain ε^2 and ε^3 increase so rapidly in time that it is impossible to find correct values for E. Therefore, the following operations were performed. The periodic term, which was not so subject to the effect of errors, was moved to the left side and the moments $M' = \text{Max} + 0.000467 \cos(0°.010433.E - 154°.3)$ were calculated. These moments are also given in the table.

In this case, each of the series of passages corresponding to a given calendar date made it possible to find the linear period formula representing the moments M'. These formulas are presented in the following table.

1 August	2.82	M'	$= 2.674408 + 0.0001020691.E_1$
2 August	3.85	M'	$= 3.733775 + 0.0001021605.E_2$
3 August	4.80	M'	$= 4.600800 + 0.0001022005.E_3$
4 August	5.77	M'	$= 5.527384 + 0.0001022633.E_4$
5 August	6.74	M'	$= 6.523804 + 0.0001022949.E_5$
6 August	7.76	M'	$= 7.728737 + 0.000102311 \;.E_6$ (Sic)
7 August	8.73	M'	$= 8.513560 + 0.0001022955.E_7$

Deviations from these formulas are given in the last column of the table.

If these deviations are represented graphically, as shown in Figure 4, then one can see that the period, after the "removal" of rapid variations, is subject to slow variations of high amplitude. The character of these variations will be clarified after all observations made between 20 July and 20 August inclusive have been processed. Efforts to clarify formula (4) appear to be premature at this time.
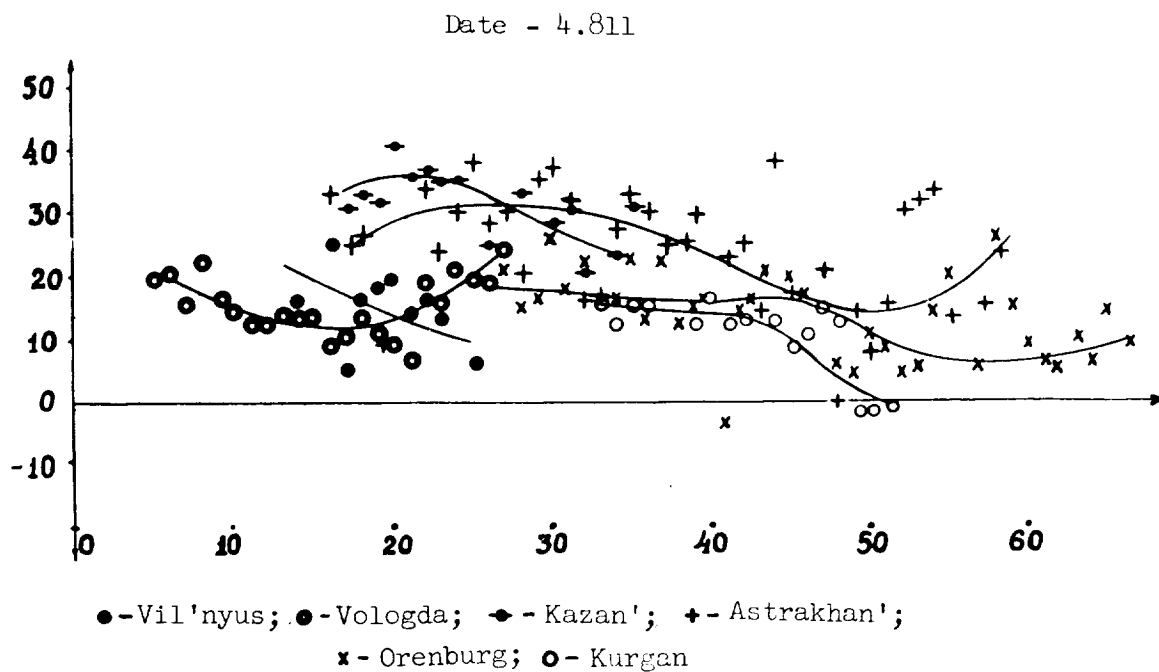
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●-Vil'nyus; ◐-Vologda; ◆-Kazan'; +-Astrakhan';
x- Orenburg; o- Kurgan

Figure 1

Date 3.816

Obs.-Cal

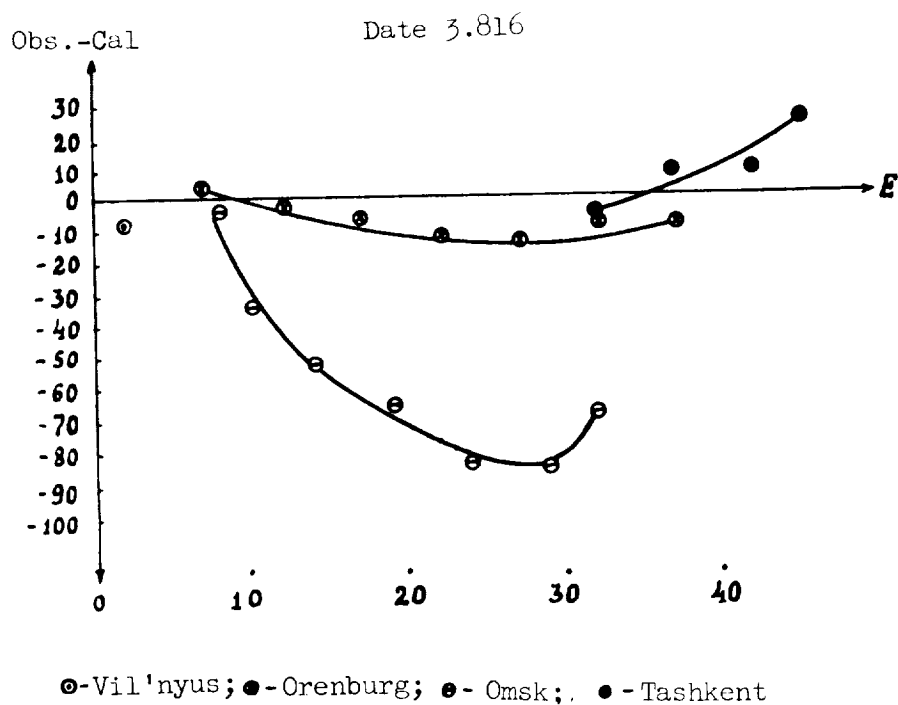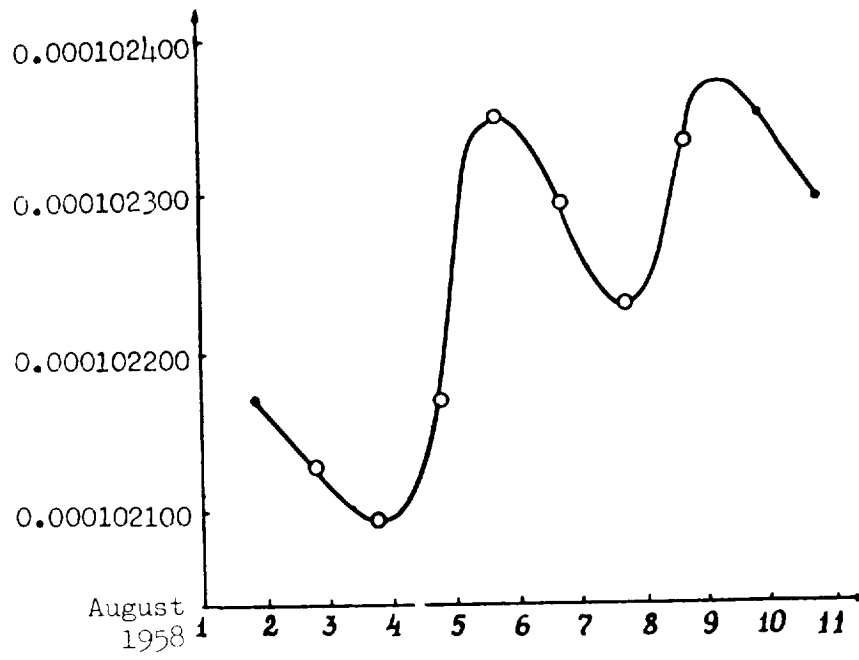⊙-Vil'nyus; ●-Orenburg; ◕- Omsk;. ●-Tashkent

Figure 2

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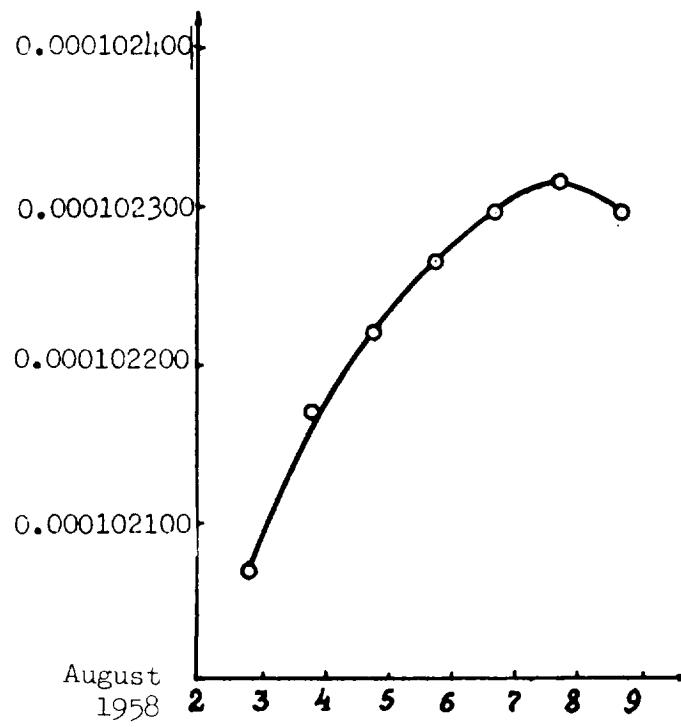
Figure 3

Figure 4

METHODS USED IN THE PHOTOMETRY OF ARTIFICIAL EARTH SATELLITES

By V. M. Grigorevskiy*

Abstract

Several methods of photometrical satellite observations are considered. In particular, a method is suggested for observing satellites with rapid brightness variations, as the satellite 1957$_B$.

Experience has shown that photographic methods do not yet permit to obtain with sufficient accuracy the light elements of artificial earth satellites at present. Thus, for example, painstaking (and very laborious) processing of a photograph taken on 20 March 1958 of satellite No 2 by V. I. Ivannikov [1] yielded a value of the period (half-period?) of rotation P = 75 s [Translator's note: apparently s = seconds], while the mean period obtained from visual observations [2] was equal to P = 209 s, which is found to be in very good agreement with the value P = 206 s obtained from an analysis of readings of instruments placed in the satellite [3]. The enormous range of changes in brightness (up to 6 - 8 stellar magnitudes) and the rapid, but irregular movement of a satellite through the celestial sphere cause considerable difficulties during the photoelectrical photometry of artificial earth satellites. Therefore, the visual method for observing the brightness of satellites and rockets still remains the basic, if not the only method. We shall now discuss this method.

Observations of Satellite No 2 were conducted in accordance with the method suggested by V. P. Tsesevich [4]. At some stations, the time moments were not directly recorded when evaluating the brightness of the satellite, but were calculated after observations on the basis of the approximate position of the satellite at the time of evaluation. Of course, this does affect the accuracy of the results. The same thing may be said about the plotting of brightness curves of an artificial satellite by many observers, each of whom makes 1 - 2 evaluations. Apparently, a greater accuracy can be achieved if 2 - 3 observers will separately follow the entire course of change in brightness, and will then average the curves obtained.

The majority of observers made their evaluations by the Neyland-Blazhko method, a method which even those who were not astronomers could readily master. The selection of comparison stars on zenith distances which are close to the zenith distances of the satellite results in a sufficiently high accuracy of observations without subsequent reductions. By knowing the path of the satellite, it is possible, as it is done in Vilna, Odessa, and other cities, to select

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in advance comparison stars. Figure 1 shows observations of Satellite
No 2, which were made in Odessa during the passage of 28 December 1957
for accuracy control independently by V. P. Tsesevich (dotted circles)
and by the author (solid circles). In spite of the fact that different
stars were used for comparison, the observations agreed completely.
In some cases, it is not possible to select comparison stars in the
immediate vicinity of the satellite, and when the observations are
processed, it is necessary to introduce corrections for differences in
the atmospheric absorption of light for different zenith distances.
For this reason, observers must also report the approximate brightness
and the comparison stars used in estimating this brightness, in addition
to reporting the brightness of the satellite and the corresponding
times according to Greenwich time. One must note that the observations
described above can also be made by a single observer. We are doing
this in the following manner: the click of a stop-watch at the moment
of firing, the evaluation of the brightness of the satellite, and the
click of the stop-watch at the moment of stop (noted in accordance with
an accurate watch or chronometer) are recorded on the tape of a tape
recorder. After the observations are completed, the evaluation of
brightness is recorded from the tape recorder, and then the corres-
ponding moments of time are taken from the stop-watch which is in
action from the time of the initial click. When using the MAG-8 tape
recorder and a stop-watch with 0.1 second divisions on its dial, the
discrepancy between the readings of the stop-watch when it is stopped
after observations and those of the tape recorder does not exceed 0.2
seconds, which is a completely satisfactory degree of accuracy. How-
ever, the above method could not be used with the third Soviet
satellite and its rocket carrier, whose brightness changed at an
exceedingly rapid rate and with great amplitude.

The third satellite was quite rarely visible to the unaided eye,
due to its great altitude above the surface of the earth. The nature
of the changes in brightness of the third satellite, not counting
individual instances when the satellite was visible for 50 - 60 seconds
and it was possible to note fairly smooth increases and decreases in
its brightness, usually corresponded to curves obtained by us on 22
(Secretary - L. Ye. Filippov) and on 25 (Secretary - N. N. Izrayetskaya)
July 1958 (Figures 2 and 3). After an almost instantaneous flare-up,
there followed a very rapid and sharp decline in brightness. Here we
were dealing apparently with a flash from some part or other of the
surface of the satellite due to specular reflection. For these reasons,
there were almost no photometric observations of the third satellite.
As of 1 January 1959, a total of 178 evaluations of brightness had been
received from four stations. Of course, these observations were wholly
inadequate for any sort of conclusions concerning the rotation of the
satellite.

Visual photometry of the rocket carrier of the third satellite proved to be a still more complex, even though entirely solvable, problem. In this case, the exceedingly rapid changes in brightness did not permit to obtain as usual, the stellar magnitude of the rocket as a function of time. Therefore, observers noted only the moments of maximum brightness. However, the accuracy of such observations was fairly low, and was equal on the average to 1 second, which is equal to over 10 percent of the interval between two successive maxima. Therefore, we suggested [5] and checked out in practice another method of observation, which makes it possible to increase by at least 4 times the accuracy of the time of maximum brightness of the satellite as determined by observations. This method may be summed up as follows. The observer dictates to the secretary or records on a tape recorder the letters "s" (slabeye - weaker) or "ya" (yarche - brighter), depending upon whether the brightness of the rocket is diminishing or growing. The corresponding moments of time are recorded with the aid of a chronograph. As a result, we are able to obtain, if not the actual brightness curve of the rocket, at least an idea of the nature of brightness changes in a certain power range. A portion of the observations of the rocket carrier of the third satellite, obtained in this manner by the author during the passage of the rocket on 27 July 1958 over the "Mayaki" [Beacons] Station at the Odessa Astronomical Observatory, is shown in Figure 4. Moments of maximum brightness were determined with an accuracy of up to 0.2 seconds, which permitted, for example, to easily correlate by means of a linear period formula the moments of maximum brightness observed during two successive passages of the rocket on 27 July 1958, in spite of the fact that observations yield a synodical,and not a sidereal period. Similar calculations performed with maximum moments which were directly recorded result in marked 0 - C deviations from linear light elements.

According to a report by B. N. Gimmel'farb, Chief of the Arkhangel'sk Station of Visual-Optical Observations of Artificial Earth Satellites, a somewhat different method of observation was developed at that station, which constitutes a further extension of the method suggested by us. These observations yielded good results.

If, when carrying out observations by the method described above, the second observer will record the stellar magnitude at minimum and maximum brightness, the method suggested by us would actually permit to obtain a brightness curve for rapidly variable satellites with a definite degree of accuracy. (It should be noted that, when observing satellites like the second satellite, which change their brightness slowly, the use of a tape recorder and a chronograph performs the same function as one observer.)

We believe that such observations can be performed at any station and will undoubtedly be applied to future satellites.

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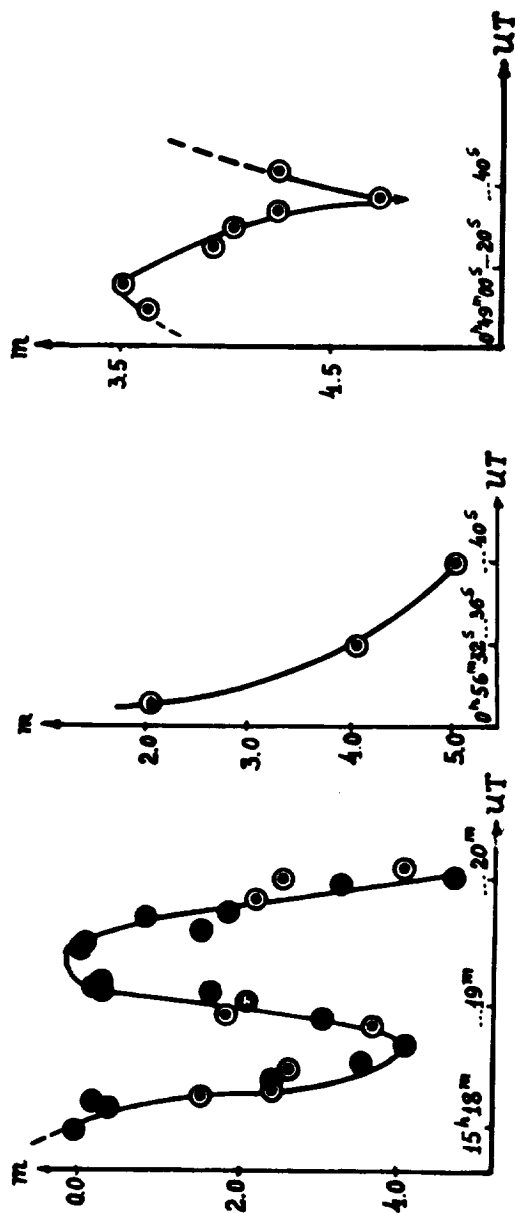
Figure 1.- Satellite No. 2; Figure 2.- Satellite No. 3; Figure 3.- Satellite No. 3;
28 December, 1957.   22 July, 1958.   25 July, 1958.
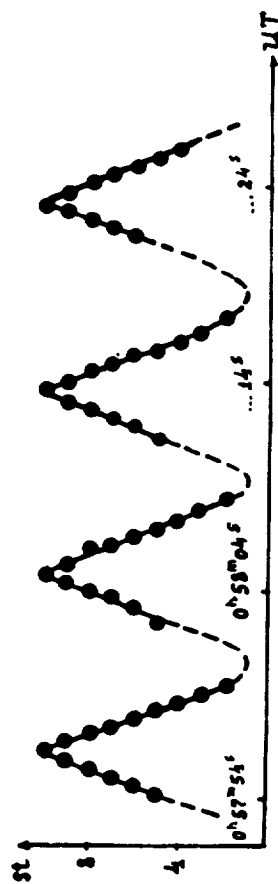
Figure 4.- Rocket Carrier of Satellite No. 3; 27 July, 1958.

CONCERNING OBSERVATIONS OF CHANGES IN THE BRIGHTNESS OF THE

ROCKET CARRIER OF THE THIRD ARTIFICIAL EARTH SATELLITE

By B. N. Gimmel'farb and V. A. Artemova*

Abstract

Moments of maximum brightness of the rocket carrier
of the third Soviet artificial satellite were registered
during October-November, 1958. Mean period of brightness
variation was established as 9$\overset{s}{.}$2, being the same for all
six observed passages.

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As is well known, the brightness of the rocket carrier of the
third Soviet artificial earth satellite (1958 δ_1) was subject to
marked and rapid variations caused by the rotation of the rocket.
In view of this, instructions sent out to all observation stations
recommended that brightness be evaluated only at times of its maxima
and minima and, in addition, that recording of times of maximum bright-
ness and of corresponding stellar magnitudes be conducted separately
by two different observers. The same instructions contained a
description of the method suggested by V. M. Grigorevskiy for deter-
mining times of maxima by means of a tape recorder.

This method was improved by us. For this purpose, A. A. Chirtsov
assembled a relay apparatus which permitted to record sound signals
of two different tones on the tape recorder with a simultaneous
recording of the sending times of these signals on a printing chrono-
graph. The observer had two telegraph keys connected with the two
different tones of the sound generator. Following uninterruptedly
changes in the brightness of the rocket, the observer would press
down, at short intervals of time, either one key, giving off signals
of one (for example, high) tone, when the brightness of the rocket
was growing, or pressing down the other key, giving off signals of
another (for example, low) tone, when the brightness of the rocket
was diminishing. After the observations were completed, it was
possible, by listening to the sound signals recorded on the tape
recorder, to mark on the chronograph tape those moments which corres-
ponded to an increasing and those which corresponded to a decreasing
brightness of the rocket. The times of maximum brightness were
determined as the average between the final recorded time of growing
brightness and the initial recorded time of diminishing brightness.
The time interval between the final recorded time of growing bright-
ness and the first recorded time of diminishing brightness could, to
a certain extent, serve as a characteristic of the sharpness of the

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Arkhangel'sk State Institute; imeni, M. V. Lomonosov.

maximum (since this is the time interval, during which the brightness of the rocket near its maximum appeared constant to the observer). Thus, it was possible to obtain a qualitative picture of the variation in brightness. In view of weather and light conditions at Arkhangel'sk, we were able to test this method only during two passages of the rocket on 17 November 1958. Deviations in individual values of the period of brightness change from the mean were noticeably smaller than in those cases in which the observer made direct recordings of the times of maximum brightness. The same value of the mean period of variation in brightness of the rocket was obtained, which was equal to 9.2 seconds in all six passages observed through October and November 1958, even though the observations were carried out by different observers who used different methods. It was not possible to detect any pattern of change in the period during any one passage of the rocket.
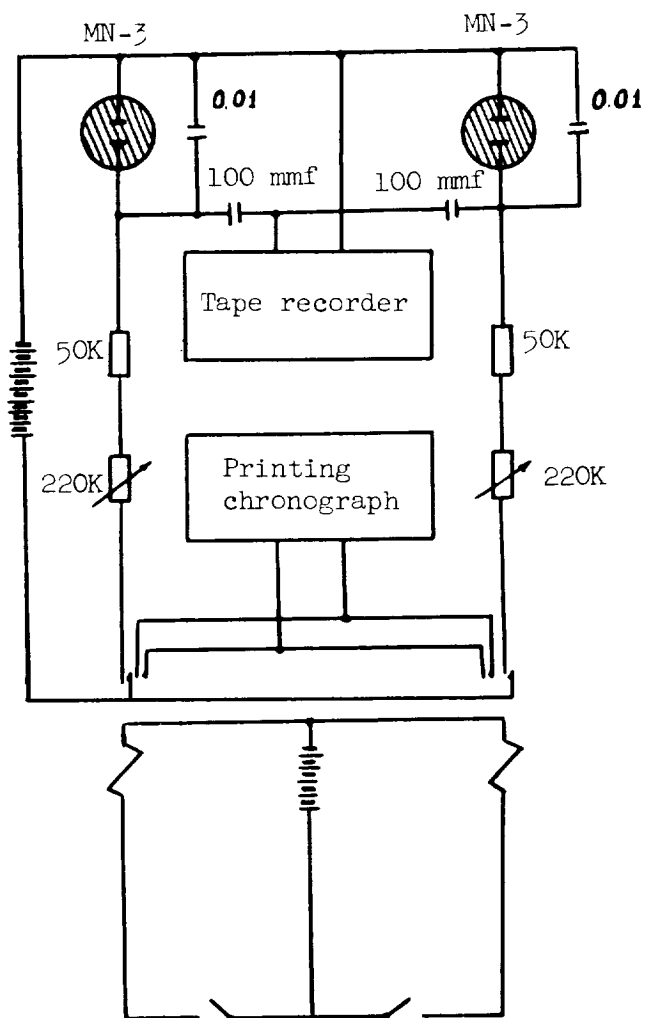
Figure 1.- Circuit of the audio frequency generator connected through
a relay with the tape recorder and printing chronograph, used in
recording signals of two different tones on the tape recorder with
simultaneous recording of the time at which these signals are fed
to the printing chronograph. [Translator's note: mmf = 10^{-2} farad.]

COMPUTER OPERATING WITH THE AT-1 TELESCOPE

By S. V. Yaroshevich*

Abstract

An automatic computer for determination of equatorial
coordinates of artificial satellites is described. The
computer works together with the telescope AT-1.

The Dnepropetrovsk Station for Visual-Optical Observation of
Artificial Earth Satellites employs, in addition to the generally
accepted barrier method, a "trapping" method, in which the object,
first noted by the unaided eye or in the barrier, is tracked with
AT-1 telescopes until the object eclipses a star or passes near a
star. At this moment, a time reading is made.

This method provides greater accuracy in determining the coordi-
nates and the time of flight of an artificial earth satellite, since
a star serves as a better orientation point than the grid of the AT-1
telescope, and if the time of passage in respect to one star is
recorded by different observers, their results can be averaged.

However, this method also has its difficulties.

1. Identification of stars from a map takes time. In addition,
during this time stars can disappear due to the approach of dawn or
the appearance of a cloud.

2. The number of noted points per observer is limited to his
memory.

Incorrect identification [of stars] can give rise to gross errors.

In order to eliminate these shortcomings, i.e., in order to save
time spent in identifying and increasing the number of points per
observer, the Dnepropetrovsk Artificial Earth Satellite Observation
Station attached to the State University has developed and built a
computing device. Together with an AT-1 telescope equipped with
transducers, this device permits to obtain automatically the equatorial
coordinates of an artificial earth satellite at the time of observation.

The computer has the following design principle:

Let us write the formulas for converting horizontal coordinates
into equatorial coordinates in the form:

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*Dnepropetrovsk artificial earth satellite observation station.

$$t = \text{arc tg } \frac{F\,(Z,A)}{H\,(Z,A,\,\varphi)}\,;$$

$$\sigma = \text{arc tg } \frac{\Im\,(Z,A,\,\varphi)}{F\,(Z,A)}\,; \tag{1}$$

where

$$\Im\,(Z,A,\,\varphi) = \sin\varphi\cos Z - \sin Z \cos A \cos\varphi$$

$$F\,(Z,A) = \sin Z \sin A \tag{2}$$

$$H\,(Z,A,\,\varphi) = \cos\varphi\cos Z + \sin\varphi\cos A.$$

Automatization of the solution of such a system of equations can be accomplished with the aid of five rotary transformers, amplifiers, cathode followers and two servomotors (see diagram 1).

According to its principle of operation, a rotary transformer is an alternating current device based on the use of the phenomenon of mutual inductance for the purpose of obtaining a sinusoidal (cosinusoidal) relationship between the secondary e. m. f. and the angle of rotation of the rotor. It has two mutually perpendicular windings both on the stator and the rotor. Therefore, both a sinusoidal and a cosinusoidal relationship are obtained simultaneously at the output. The structural design of the rotary transformer is similar to the design of selsyns.

Two rotary transformers are connected with an AT-1 telescope. The output voltage of the first rotary transformer VT-1 is proportional to sin Z and cos Z, since the axis of the transformer rotor is connected with the horizontal rotation axis of the AT-1 telescope. A voltage, which is proportional to sin Z, is fed to the input of the primary winding of the second rotary transformer VT-2, the rotor of which rotates together with the azimuthal rotation of the telescope. Its output voltage is proportional to sin Zsin A = F(Z,A) and sin Zcos A. The voltages cos Z from VT-1 and sin Zcos A from VT-2 are fed into two potentiometers, which are regulated so that their output voltages will be proportional to cos Zcosφ ; sinφcos Z to P_1 and -cos A sin Z cosφ; cos A sin Z sinφ to P_2.

After summing on amplifiers U_1 and U_2, we obtain

$$\Im\,(Z,A,\varphi) = \sin\varphi\cos Z - \sin Z \cos A \cos\varphi$$

$$H\,(Z,A,\,\varphi) = \cos Z \cos\varphi - \sin Z \cos A \sin\varphi \tag{2A}$$

i.e., we have obtained expressions (2).

Rotary transformers are also used to solve equation (1). Voltages proportional to F (Z,A) and H (Z,A, φ) are fed into two mutually perpendicular windings of the stator of rotary transformer VT-3 and, due to its properties, the following voltage is obtained on the rotor winding:

$$U = H (Z,A, \varphi) \sin\beta - F (Z,A) \cos\beta, \qquad (2D)$$

where β is the angle of rotation of rotor VT-3.

By turning the rotor, we find the position at which U = 0, that is, at the time that $\beta^o = t^o$. VT-4 is mounted coaxially with the rotor of VT-3, which, being fed with a voltage proportional to J (A,Z, φ), will give at its output J (A,Z, φ) sin t. Feeding this voltage and F (Z,A) into the stator winding of VT-5, in the same way as we found t^o, we obtain σ^o by turning the rotor of VT-5 to zero of the output voltage. The process of finding the zero voltage on the rotors is readily automatized by servomotors M_t and M_σ, which find this position on "their own" and stop if they are fed from the windings of the rotors through power amplifiers U_3 and U_4.

The zero point on the azimuth is established by pointing the AT-1 telescope at the North star, taking into account its movements.

The position of the stator of rotary transformer VT-2 is set to zero voltage on the sine winding, and the stator is then rigidly fixed. An oscillograph serves as an indicator. The accuracy of the zero point setting depends upon the type of rotary transformer and can be brought to 0.1 degrees. The setting of zero point Z is done in the same manner according to the zenith star.

At present, the method for conducting observations with this computer consists of the following: the time at which an object passes "close to the star" is recorded with the key, and the center of the telescopic cross-wire is then trained on this spot. The device gives t^o and σ^o in the form of scale readings, and after these readings are recorded by the observer, the telescope may be used for further observations.

In case of manual adjustment, the solution time amounts to 0.5 to 1 minute, and is considerably shorter in case of automatic computation.

At present, this computer has an accuracy of 2° - 3°, which allows the identification of stars on the star map.

One computer can serve several telescopes equipped with transducers (rotary transformers).

As a result of a more painstaking assembly of the computer and the use of high-precision rotary transformers, the accuracy can be increased to $\pm$ 0.3°; in this case, the computer could be used for the direct observation of artificial earth satellites. An observer will then be able to obtain several points located directly in equatorial coordinates during one flight. Recalculation is not required here, as in the case of observations performed with the aid of theodolites or with devices giving horizontal object coordinates.

It will be possible to conduct observations without the aid of stars, on the sole condition that the satellite will be visible in a telescope. By adding switches, the computer will be able to solve the reverse problem, namely finding the horizontal coordinates of a point with known equatorial coordinates.

Note:

To increase the accuracy of the computer, it would be expedient to:

1) Replace the functional potentiometers for introducing $\sin \varphi$ and $\cos \varphi$ with sine-cosine rotary transformers. This would decrease the unavoidable phase shift in the circuit.

2) Use SKVT [Meaning of this abbreviation is not clear] as adding and subtracting transformers.

At present, an analogous diagram for inverse transformation has been developed at the Institute of Electromechanics of the Academy of Sciences, USSR.

Senior Scientific Associate,   N. N. Mikhel'son
Main Astronomic Observatory of
the USSR Academy of Sciences

Figure 1
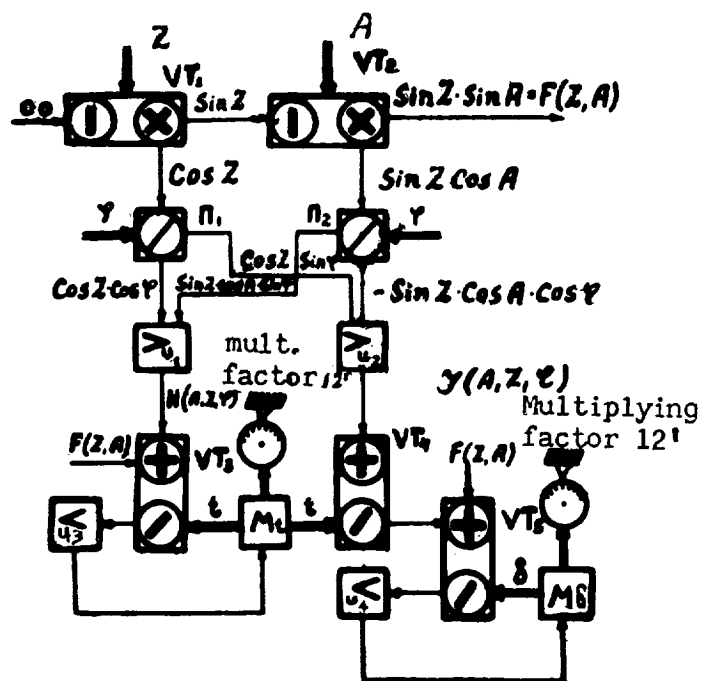
SPECIAL SATELLITE PLATE HOLDER ("Sp. K")

By Ye. Ya. Bugoslavskaya*

Abstract

A plate-holder is described allowing to obtain time
marks on the satellite image by means of a moving
grating placed in front of the plate.

Acting on an idea suggested by Ye. Ya. Bugoslavskaya in 1957,
Engineer N. I. Yakovlev, of the State Astronomical Institute Imeni
P. K. Shternberg, designed and assembled (with the aid of the institute
workshop) a special plate holder to be used in large astronomical
cameras for photographing the rocket carrier of artificial earth
satellites with time marking. The principle of this device is based
on the fact that a motor-propelled grid of parallel lines moves in
front of a photographic plate; at certain positions of the grid a
current is switched on in the plate holder circuits and the contacts
are recorded on a chronograph. The grid lines intersect the path of
the flying object, forming breaks in its picture. By determining the
position on the plate of these breaks in the track in relation to the
position of the grid lines at contact times, the time corresponding
to these track spots can be established with great accuracy, and
their exact α and δ coordinates can be determined with the aid of
reference stars.

Such a plate holder can be built according to different designs.
In our case, the plate holder was designed for a wide-angle astro-
metrical astrograph (AFR-1) with a focus of 2.3 m and a plate field of
$6^\circ \times 6^\circ$. In order to recognize the number of grid lines according
to the breaks in the track of the object, the lines were spaced at
different intervals and distributed in groups of different sequences.

Tests of the "Sp. K" performed by Ye. Ya. Bugoslavskaya and I. A.
Khasanov yielded good results. The grid lines giving breaks in the
track were readily identified. The position of the grid lines at
contact times was successfully determined with the aid of a gas dis-
charge tube, which is connected to the circuit of the holder. This
tube flashed at contact times, lighting up the plate inserted in the
holder and printing the lines on this plate.

In order to successfully photograph the object under different
flight conditions, it is important that the holder section of the
instrument should rotate with the positional angle. In case of a
rapid movement of the grid, it was essential that the grid lines form

*State Astronomical Institute; imeni, P. K. Shternberg.

a small angle with the trajectory (as in our case, when the speed of the grid was equal to about 58 mm per second). In case the grid moves slowly, the grid lines must form an angle of about 90° with the trajectory.

The greater is the speed of the grid, the less accurately can the position of the grid lines at contact times be determined. In our case, measurements of the positions of the lines up to 0.1 mm resulted in a moment error of less than 0.002 seconds.

Using photographs of 30/31 July 1958 of the rocket carrier of the third satellite, I. A. Khasanov determined the coordinates of the track breaks formed by the 37th group of lines.

	α 1950.0	δ 1950.0	ΔT_0	T_0 x)
Start of the break	$21^h32^m07^s42$	$+65°11'42''7$		$21^h28^m52^s75$
End " " "	21 32 20.97	+ 65 09 38.7	0^s166	
Start " " "	21 32 39.06	+ 65 06 59.3		21 28 52.92
End " " "	21 32 46.93	+ 65 05 54.9	0.153	
Start " " "	21 33 07.51	+ 65 02 44.4		21 28 53.07
End " " "	21 33 13.18	+ 65 01 51.4		

x)The absolute correction of the chronometer was determined with an uncertainty of 0.5 seconds.

A METHOD FOR PHOTOGRAPHING THE ROCKET CARRIER OF

THE THIRD ARTIFICIAL EARTH SATELLITE BY MEANS

OF NARROW FILM (35 mm) CAMERAS

By F. M. Poroshin*

Abstract

Rocket carrier of the third Soviet satellite was
photographed with a camera of "FED-2" type. Breaks in
the image (for determining the time) were made by a
shutter from a camera "Photocor."

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The photographic method for observing the rocket carrier of the
third artificial earth satellite ($1958 \alpha_1$) differed considerably from
the previously suggested method for photographic observation of the
second artificial earth satellite (1957β) due to its rapid changes
in brightness with a period of about 8 seconds. A. I. Landratov, a
student of the Physics-Mathematics Department, used a FED-2 camera
to photograph the rocket at the Omsk Station.

The camera was fastened with the aid of a universal telescopic
support to a metal tripod for binoculars, available in sufficient
numbers at the station.

A frame view finder, built at the station, was installed in the
view finder socket of the camera to determine the field of vision
of the camera.

A shutter from a "Fotokor" camera was mounted on the objective
of the "FED-2" camera. With this shutter, the time was noted at which
the shutter was closed (for this purpose the shutter release lever
should be insulated from the body of the shutter, and one wire from
the two-wire line of the printing chronograph was attached to the body
of the shutter). The second wire was connected to the body of the
shutter in such a way that a short-circuit occurred when the shutter
was closed.

Prior to the start of observations, the shutter of the "FED-2"
camera was open and set for prolonged exposure. When the rocket
appeared in the field of vision of the frame view finder, the "Fotokor"
shutter was opened and the number of brightness maxima was counted.
At the third brightness maximum, the "Fotokor" shutter was closed.
Next, the time was noted on the chronograph, and the control stop-
watch was started at the same time. The shutter was again immediately
opened, since a minimum brightness had already set in and the track of

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*Omsk artificial earth satellite observation station.

the rocket no longer appeared on the film. In a like manner, the
"Fotokor" shutter was closed at the fifth maximum, after which the
shutter was opened and the track of the rocket was photographed up to
the limit of the camera's field of vision. Ten to twelve brightness
maxima were obtained on the negative, of which the third and the fifth
were "shorted" by closing the shutter and making a corresponding time
mark.

The camera was then pointed to the next sector of the sky, and
the track of the rocket was similarly photographed on the next frame.

For successful photographic work, a secretary is needed, who
should note the number of maxima photographed on each frame and at
which maxima the time corresponding to a break in the rocket was
noted.

The method developed here was used at our station, and the time
was recorded on a tape recorder and on stop-watches. With two printing
chronographs on hand at the station, one can be used for photographic
observations of bright satellites and rockets.

RESULTS OF PHOTOGRAPHIC OBSERVATIONS OF ARTIFICIAL EARTH SATELLITES

Latvian State University

$\varphi = + 56° 57' 08''$ $\qquad$ $\lambda = 1^h 3.6^m 28^s08$ $\qquad$ $h = 39 \pm 2M.$

NAFA 3c/25 Camera $\qquad\qquad$ Panchromatic film, type 10

Date	U.T.	α 1950.0	δ 1950.0

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Second Satellite (1957 β)

	Date	U.T.	α 1950.0	δ 1950.0
1	8 April 1958	$18^h36^m25^s497$	$16^h00^m35^s$	$+ 53°10'3$

Third Satellite (1958 δ_2)

	Date	U.T.		
1	7 July 1958	$21^h12^m33^s904$	$17^h53^m00^s$	$51°57'7$
2	"	21 12 36.350	18 07 20	54 37.6
3	"	21 12 39.009	18 28 06	57 47.2

Rocket of the Third Satellite (1958 δ_1)

	Date	U.T.		
1	29 June 1958	$23^h45^m38^s672$	$20^h44^m56^s$	$35°12'2$
2	7 July 1958	21 18 42.554	14 45 44	74 45.0
3	1 August 1958	21 24 21.321	22 54 23	72 34.2
4	"	21 24 37.687	23 07 33	63 43.7
5	"	23 10 27.642	19 19 31	12 10.5
6	"	23 10 47.025	19 42 41	08 57.6
7	3 August 1958	21 16 37.577	12 30 28	51 28.3
8	"	21 18 28.852	19 27 18	67 22.2
9	"	21 18 36.350	19 57 48	64 38.4
10	"	21 18 52.776	20 45 24	58 13.9
11	"	23 03 30.83	17 41 13	13 57.9
12	"	23 04 18.708	18 31 21	08 13.8
13	"	23 04 25.52	18 37 57	07 22.4
14	7 August 1958	20 58 03.886	16 30 09	44 55.1
15	"	20 58 16.020	17 00 57	43 30.4
16	"	20 58 37.294	17 51 53	39 42.8
17	"	20 59 56.953	19 59 21	19 36.7
18	"	21 00 33.365	20 31 11	11 42.2
19	11 August 1958	20 32 33.382	17 33 33	20 23.4
20	"	20 32 42.687	17 45 55	18 36.6
21	30 September "	02 34 25.013	20 15 27	56 45.0
22	"	02 34 26.637	20 11 10	56 39.1
23	"	02 34 33.473	19 51 59	59 11.9

	Date	U.T.	α 1950.0	δ 1950.0
24	30 September1958	$02^h35^m06^s.563$	$17^h48^m20^s$	$64°46.8"$
25	"	02 35 18.182	17 00 13	64 48.6
26	"	02 35 23.649	16 36 19	64 14.4
27	"	02 35 54.535	15 03 16	59 55.6
28	"	02 36 04.972	14 40 59	57 49.0
29	"	02 36 15.456	14 22 44	55 39.2

Observers: M. K. Abele, E. Ya. Zablovskis

Processing: Abele, M.K., Zablovskis, E. Ya., Valbis, Ya. A.

1958 δ_1

		Date	U.T.	α 1950.0	δ 1950.0
30	1	October 1958	$01^h37^m33^s.532$	$15^h07^m45^s$	+72°55.9
31			01 37 45.497	14 10 29	+69 26.7
32	2	"	02 20 13.155	17 36 38	+62 58.5
33		"	02 20 19.527	17 13 11	+ 63 11.7
34		"	02 20 29.479	16 37 15	+63 02.3
35	3	"	03 02 02.460	20 04 13	+53 01.0
36		"	03 02 15.280	19 40 34	+55 20.7
37		"	03 02 15.646	19 38 59	+55 40.6
38		"	01 21 48.734	13 57 35	+64 37.6
39		"	01 21 51.114	13 51 17	+64 10.2
40		"	01 22 03.382	13 22 43	+60 49.3
41	4	"	02 00 30.078	18 10 57	+60 35.9
42		"	02 00 42.445	17 33 39	+61 52.1
43		"	02 00 52.515	16 55 47	+62 24.2
44		"	02 00 56.854	16 40 53	+62 25.7
45		"	02 01 51.267	14 15 29	+56 04.2
46		"	02 02 00.848	13 59 22	+54 18.2
47	15	"	03 02 49.108	00 23 12	+56 30.2
48		"	03 02 54.841	00 35 12	+57 34.2
49		"	03 03 02.744	00 53 48	+58 59.3
50		"	03 03 22.988	01 53 59	+61 55.2
51		"	03 03 33.627	02 33 05	+62 46.0
52		"	03 03 49.618	03 37 32	+62 38.0
53		"	03 03 55.744	04 02 34	+62 04.3
54		"	03 04 23.717	05 42 32	+56 05.9
55		"	03 04 28.233	05 55 35	+54 42.3
56		"	03 05 27.599	07 38 59	+34 07.2
57		"	03 05 41.075	07 52 48	+29 48.4
58		"	03 05 52.487	08 01 01	+26 24.5
59		"	03 06 05.089	08 09 42	+22 56.3

	Date	U.T.	α 1950.0	δ 1950.0
60	15 October 1958	$03^h06^m28^s.581$	$08^h23^m02^s$	$+17°12'.7$
61	"	03 06 44.955	08 30 41	+13 43.4
62	"	03 06 46.396	08 31 20	+13 25.8
63	"	03 06 55.745	08 35 10	+11 37.5
64	"	03 07 29.032	08 46 55	+06 01.4
65	"	03 07 04.707	08 38 34	+10 00.2
66	"	03 07 38.372	08 49 24	+04 39.3
67	"	03 07 58.578	08 52 51	+02 49.2
68	"	03 08 00.027	08 54 41	+01 44.1
69	16 "	03 30 54.997	06 12 32	+16 21.9
70	"	03 31 02.795	06 20 55	+14 43.7
71	"	03 31 12.017	06 30 14	+12 50.9
72	3 November 1958	16 27 48.779	15 45 43+1	+26 17.2+0'1
73	"	16 29 12.792	13 34 17+5	+70 42.5 "
74	"	16 29 48.323	8 15 54+5	+74 47.5 "
75	13 "	16 22 44.473	12 14 27+1	+47 22.7 "
76	"	16 22 45.807	12 12 36+1	+47 38.4 "
77	"	16 23 55.774	9 47 23+2	+59 16.5 "
78	"	16 25 05.791	6 36 23+2	+53 26.7 "

Error in determining time $\pm$ 0.006 sec
Observers: E. Ya. Zablovskis, E. E. Tardenaks
Processing: E. Ya. Zablovskis, Y. A. Valbis
Measurements were taken on UIM-21

Chief of the Photographic Station   E. Ya. Zablovskis

Tashkent Astronomical Observatory of the Academy of Sciences of the Uzbek SSR

$\varphi = + 41°19'33''.3;$ $\lambda = 4^h37^m10^s.476;$ $h = 476$ M.

NAFA 3c/25   Panchromatic film, type DK

1958 δ_1

	Date	U.T.	α 1950.0	δ 1950.0
1	9 August 1958	$17^h22^m02^s.710$	$01^h06^m00^s.2$	$+59°42'22''$
2	"	17 22 03.120	01 05 28.1	+59 35 58
3	"	17 22 11.004	00 56 17.6	+57 41 04
4	"	17 22 11.513	00 55 42.7	+57 32 58
5	10 "	17 14 01.651	00 32 46.8	+60 38 40
6	"	17 14 01.771	00 32 34.9	+60 36 13

	Date	U.T.	α 1950.0	δ 1950.0
7	10 August 1958	$17^h14^m10^s272$	$00^h23^m32^s5$	$+58°19'10$
8	"	17 14 10.769	00 23 00.3	+58 10 39
9	12 "	16 55 41.071	23 19 08.9	+60 00 09
10	"	16 55 41.322	23 18 57.5	+59 54 49
11	"	18 38 52.234	15 29 16.1	+28 02 38
12	"	18 38 52.805	15 29 48.4	+27 59 09
13	"	18 39 01.040	15 36 56.9	+27 11 25
14	"	18 39 01.721	15 37 34.1	+27 06 50
15	13 "	16 44 36.911	23 36 22.8	+75 21 06
16	"	16 44 37.394	23 35 20.8	+75 12 10
17	"	18 29 02.449	15 48 35.0	+22 41 33
18	"	18 29 02.757	15 48 52.6	+22 38 53
19	"	18 29 11.231	15 55 46.4	+21 38 29
20	"	18 29 11.575	15 56 04.7	+21 35 43
21	14 "	16 34 08.346	22 21 00.7	+64 38 57
22	"	16 34 16.144	22 17 58.3	+61 59 04
23	"	16 34 17.188	22 17 35.9	+61 36 58
24	"	18 17 09.230	15 03 32.4	+25 52 33
25	"	18 17 09.764	15 04 00.3	+25 49 18
26	15 "	18 05 05.439	14 44 57.9	+25 54 20
27	"	18 05 05.922	14 45 19.6	+25 51 58
28	"	18 05 13.889	14 51 17.9	+25 11 50
29	"	18 05 14.450	14 51 43.7	+25 08 42
30	16 "	16 09 43.625	21 24 43.7	+66 04 11
31	"	16 09 51.783	21 24 44.3	+63 10 33
32	"	16 09 53.150	21 24 43.8	+62 41 11

Observers: A. Latypov, A. Kadyrov, A. Rakhimov, G. Kim, and Yu. Ivanov.

Measurements were made on the KIM-3 device by Scientific Associate A. Kadyrov. The measurements were processed by him according to Professor A. N. Deych's method (when $\delta > 60°$, terms of the third order are taken into account); Laboratory Assistants R. Sultanbekov and F. Sattarova participated in processing the measurements.

All times of exposure mentioned here are reduced to standard time.

Chief of the Photographic Station   A. A. Latypov

News Items

The first issue of the Byulleten' stantsii vizual'nykh nablyudeniy pri Turkmenskom gosudarstvennom pedagogicheskom institute im. V. I. Lenina [Bulletin of the Station for Visual Observations Attached to the Turkmen Pedagogical Institute Imeni V. I. Lenin] has been published. The bulletin will be published in 1,000 copies by the station once a month.

The first issue of the bulletin contains an article on the work done by the Station for Optical Observation of Artificial Satellites, also articles and reports on meteoric astronomy in the city of Chardzhou.

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APPENDICES

I.   Observations of Artificial Earth Satellites by Soviet Stations[*]

II. Observations of Artificial Earth Satellites by Foreign Stations

[*]Information taken from telegrams from observation stations.

Appendix I

Table 1

Observations of the Third Artificial
Earth Satellite (1958 δ_2)

Number of Station	Name of Station	April		May	
		Number of Observations	Number of Passages	Number of Observations	Number of Passages
1	Abakan	1	1	6	3
2	Alma-Ata	-	-	-	-
3	Abastumani	24	9	38	16
4	Arkhangel'sk	63	18	29	8
5	Astrakhan'	35	11	61	18
6	Ashkhabad	62	10	51	11
7	Baku	-	-	2	2
8	Barnaul	10	3	23	5
9	Batumi	9	5	-	-
10	Blagoveshchensk	31	15	101	30
11	Bukhara	16	10	19	14
12	Vil'nyus	76	18	156	38
13	Vladivostok	14	8	35	12
14	Vologda	111	23	144	32
15	Voronezh	10	4	-	-
16	Gor'kiy	21	10	20	8
17	Dnepropetrovsk	35	12	37	17
18	Yerevan	1	1	34	16
19	Irkutsk	11	5	16	10
20	Kazan'	30	15	38	15
21	Karaganda	5	3	8	4
22	Kzyl-Orda	-	-	24	13
23	Kiev	41	23	50	25
24	Kishinev	-	-	5	3
25	Komsomol'sk Amur	24	14	21	15
26	Krasnoyarsk	25	11	19	11
27	Krasnodar	11	4	29	11

Table 1 (continued)

Number of Station	Name of Station	April Number of Observations	April Number of Passages	May Number of Observations	May Number of Passages
28	Crimean Observatory	19	8	20	9
29	Kurgan	23	11	32	16
30	Leningrad	11	6	26	8
31	L'vov	25	15	11	8
32	Perm'	19	9	28	14
33	Minsk	19	8	26	11
34	Moscow	23	9	14	6
35	Novosibirsk	48	15	121	27
36	Odessa	26	13	30	14
37	Omsk	74	20	164	36
38	Petrozavodsk	23	10	16	11
39	Pulkovo	38	13	33	19
40	Riga	86	28	147	46
41	Rostov Don	42	11	53	17
42	Ryazan'	63	15	50	17
43	Samarkand	31	10	35	13
44	Saratov	59	18	144	33
45	Sverdlovsk	37	13	100	34
46	Smolensk	65	27	42	22
47	Stalinabad	5	3	4	4
48	Stalingrad	111	20	235	41
49	Syktyvkar	47	15	47	16
50	Gor'kiy	23	12	11	7
51	Tartu	-	-	-	-
52	Tashkent	-	-	-	-
53	Tbilisi	-	-	7	3
54	Tomsk	38	13	25	11
55	Uzhgorod	35	13	47	20
56	Ulan-Ude	21	19	25	22
57	Ufa	18	9	75	34
58	Frunze	6	3	39	12
59	Khzbarovsk	26	5	159	20
60	Khar'kov	9	6	13	8
61	Chardzhou	4	3	23	9
62	Chernovtsy	39	13	31	15
63	Orenburg	54	20	78	34
64	Chita	46	19	87	33
65	Yuzhno-Sakhalinsk	14	6	24	12
66	Yakutsk	2	2	5	4
67	Alma-Ata	1	1	-	-

Table 1 (continued)

Number of Station	Name of Station	April		May	
		Number of Observations	Number of Passages	Number of Observations	Number of Passages
68	Stalinabad	-	-	-	-
69	Kungur	-	-	19	9
70	Kiev Main Astronomical Observatory	22	11	17	11
71	Ul'yanovsk	35	16	63	13
72	Moscow Astrosovet (Astronomical Council)	-	-	-	-
73	Odessa	-	-	-	-
74	Ashkhabad	-	-	-	-
75	Tashkent	-	-	-	-
76	Observatory Imeni Engel'gardt	21	8	65	18
77	Nikolayev	25	8	32	15
80	Nal'chik	31	10	21	6
82	Byurakan	-	-	-	-
83	Tartu	136	23	135	28
84	Riga	3	3	-	-
	Total	2164	752	3346	1109

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Appendix II

Table 2

Observations of the Third Artificial Earth Satellite

Number of Station	Country	Name of Station	April		May	
			Number of Passages	Number of Observations	Number of Passages	Number of Observations
101	Bulgaria	Sofia	10	45	9	57
111	Hungary	Budapest	2	3	1	1
112		Szombathely	2	2	-	-
113		Baja	2	3	-	-
120	German	Bautzen	-	-	1	?
121	People's	Potsdam	19	107	25	291
122	Republic	Sonneberg	-	-	-	-
123		Kyulunsborn [literal]	11	14	3	4
124		Eilenburg	1	1	3	6
125		Rodewisch	5	13	13	21
126		Jena	-	-	-	-
127		Potsdam-Babelsberg	-	-	-	-
128	German	Lubeck	-	-	1	1
129	Federal	Bergedorf	-	-	-	-
130	Republic	Bonn	-	-	-	-
135		Darmstadt	-	-	-	-
136		Hannover	-	-	2	2
131	Rumania	Bucharest	8	29	9	35
132		Cluj	10	31	13	41
141	Czecho-	Ondrzheyov	-	-	-	-
142	slovakia	Skalnate Pleso [literal]	-	-	1	3
143		Brno	1	1	8	17
144		Bratislava	17	60	15	50
145		Praha I	3	11	9	44
146		Plzen I	-	-	-	-
147		Ceske Budejovice	-	-	-	-
150		Praha II	-	-	-	-
171		Pet-i [literal]	-	-	-	-
172		Pezhinek [literal]	-	-	-	-
173		Golemov [literal]	-	-	-	-
174		Plzen II	-	-	-	-
175		Prerov	-	-	-	-

Table 2 (continued)

Number of Station	Country	Name of Station	April		May	
			Number of Passages	Number of Observations	Number of Passages	Number of Observations
151	Poland	Torun	-	-	-	-
152		Wroclaw	-	-	-	-
153		Krakow	-	-	-	-
154		Poznan	-	-	3	3
155		Warsaw	2	2	-	-
156		Gdynia I	-	-	3	5
157		Zgierz	14	57	9	27
158		Jelena Gora	-	-	-	-
159		Torun II	-	-	-	-
160		Josefoslawo	-	-	-	-
	Japan		12	23	20	24
271	China	Peiping	20	72	28	70
272		Nanking	7	19	6	9
273		Lanchow	4	7	3	5
274		Kunming	-	-	7	19
275		Lhasa	-	-	-	-
276		Canton	1	1	8	28
277		Hsian	5	14	11	37
278		Shanghai	4	6	4	7
279		Wuhan	-	-	1	1
280		Changchun	19	59	30	127
281		Urumchi	13	35	19	34
282		Tientsin I	16	74	28	87
283		Tsao-Tsze [literal]	-	-	-	-
284		Harbin	14	27	28	71
285		Huhehaote [literal]	16	39	28	62
286		Sining	-	-	-	-
287		Chengchow	4	9	22	64
288		Chengtu	7	20	-	-
289		Tsingtao	-	-	9	24
290		Fuchow	3	3	5	18
291		Hanking	2	3	6	18
292		Shantow	1	2	10	18
293		Tientsin II	-	-	-	-
301	Argentina	Tucuman	-	-	-	-
302		Buenos Aires	-	-	-	-
303		Pergamino	-	-	-	-
304		Merlo	-	-	-	-
305		Cordoba	-	-	-	-
306	Chili	Santiago	-	-	-	-

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Table 2 (continued)

Number of Station	Country	Name of Station	April Number of Passages	April Number of Observations	May Number of Passages	May Number of Observations
307	Uruguay	Montevideo	-	-	-	-
308	Ecuador	Quito	-	-	-	-
309		Guangiltagua [literal]	-	-	-	-
321	Peru	Arequipa	-	-	-	-
322		Huancayo	-	-	-	-
323		Ancon	-	-	-	-
351	Brazil	Sao Paulo	-	-	-	-
352		Bauru	-	-	-	-
401	Great	Macclesfield	-	-	-	-
402	Britain	Cambridge	-	-	-	-
403		Herstmonsow [literal]	-	-	-	-
404		Edinburgh	-	-	-	-
406		Slough	2	2	-	-
410		Fareham	-	-	1	1
407	Ireland	Dublin	-	-	-	-
450	France	Meudon	13	54	23	277
451		Pic du Midi	-	-	-	-
471	Austria	Vienna	-	-	-	-
472		Kantselhohe	-	-	-	-
501	Yugoslavia	Belgrad	14	51	9	34
502		Zagreb	-	-	-	-
503	Greece	Athens	-	-	-	-
504		Pentele [literal]	-	-	-	-
505		Spetsai [literal]	-	-	2	3
506		Thessaloniki	-	-	-	-
507		Ikaria	-	-	-	-
551	Pakistan	Dakka	-	-	-	-
552		Quetta	-	-	-	-
571	Indonesia	Jakarta	-	-	-	-
572		Lembang	-	-	-	-
581	Viet Nam	Hanoi	-	-	-	-
601	Australia	Canberra	-	-	-	-
602		Sydney	-	-	-	-
603		Perth	-	-	-	-
604		Adelaide	-	-	2	5
605		Melbourne	-	-	-	-
606		Woomera	-	-	1	1

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Table 2 (continued)

Number of Station	Country	Name of Station	April Number of Passages	April Number of Observations	May Number of Passages	May Number of Observations
660	Mongolia	Ulan-Bator	-	-	-	-
771	Canada	Ottawa	-	-	2	2
772		Richmond Hill	-	-	-	-
773		Athabasca	-	-	-	-
774		Newbrook	-	-	-	-
775		Royal Oak	-	-	-	-
776		Saskatoon	-	-	-	-
777		Vollecartiere	-	-	-	-
801	Netherlands	Station No 1	-	-	1	1
802		Station No 2	-	-	-	-
803		Station No 3	-	-	-	-
804		Station No 4	-	-	-	-
805		Station No 5	-	-	-	-
806		Station No 6	-	-	-	-
807		Station No 7	-	-	-	-
808		Station No 8	-	-	-	-
810		Station No 10	8	21	16	46
811		Station No 11	-	-	-	-
812		Station No 12	-	-	-	-
813		Station No 13	-	-	-	-
814		Station No 14	-	-	-	-
815		Station No 15	-	-	-	-
816		Station No 16	-	-	-	-
817		Station No 17	-	-	-	-
818		Station No 18	-	-	-	-
901	United Arab Republic	Helwan	-	-	-	-
930	Union of South Africa	Johannesburg	-	-	-	-
931		Bloemfontein	-	-	-	-
932		Capetown	-	-	-	-
942	Finland	Niinisalo [literal]	-	-	-	-
963		Jokkoinen [literal]	11	228	31	549
	United States		18	18	23	23
	Total		321	1251	512	2270

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